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(71) Applicant
General Electric Company (USA-New York),
1 River Road, Schenectady 12305, State of New York,
United States of America

(72) Inventors
Thomas Halpin Fitzgerald,
James Reynolds Patterson,
Nicholas Francis Sampieri

(74) Agent and/or Address for Service
Paul M. Turner and Company,
47 Marylebone Lane, London W1M 6DL

(54) Built-up roofing comprising silicone-rubber-coated glass fabric

(57) The roofing comprises a roof deck 12 overlaid by an insulating layer 14 which is in turn overlaid by a single-ply membrane layer 16 of glass fabric coated with silicone rubber. The membrane layer is bonded to the insulating layer by either (i) a silicone-rubber pressure-sensitive adhesive 18 or (ii) a silicone sealant bead 22 around the membrane perimeter, together with a ballasting layer of roofing granules 20, or by (iii) a combination of (i) and (ii).

The membrane layer 16 may be prefabricated, or glass fabric may be laid and coated *in situ*.

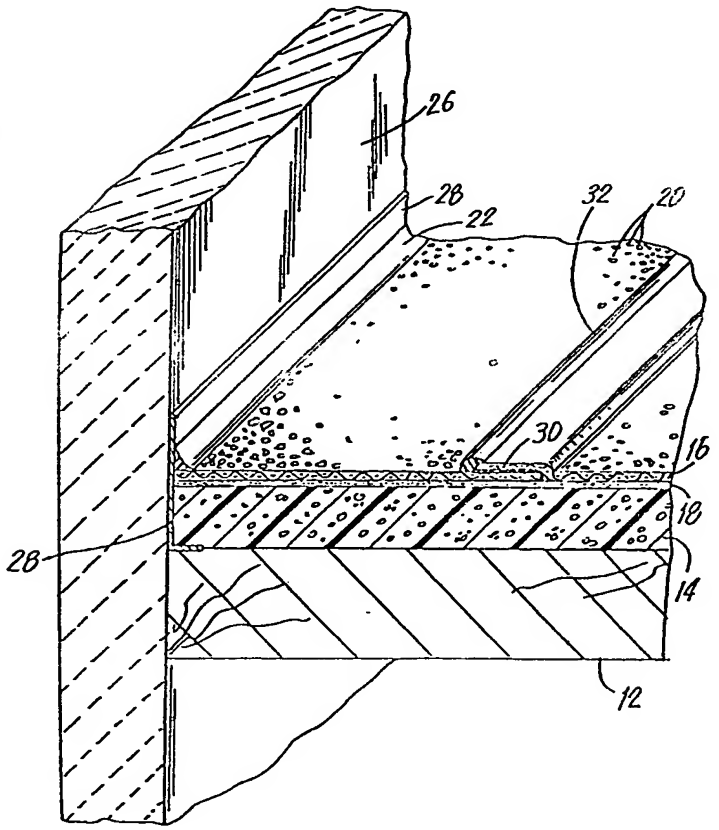

FIG. 2

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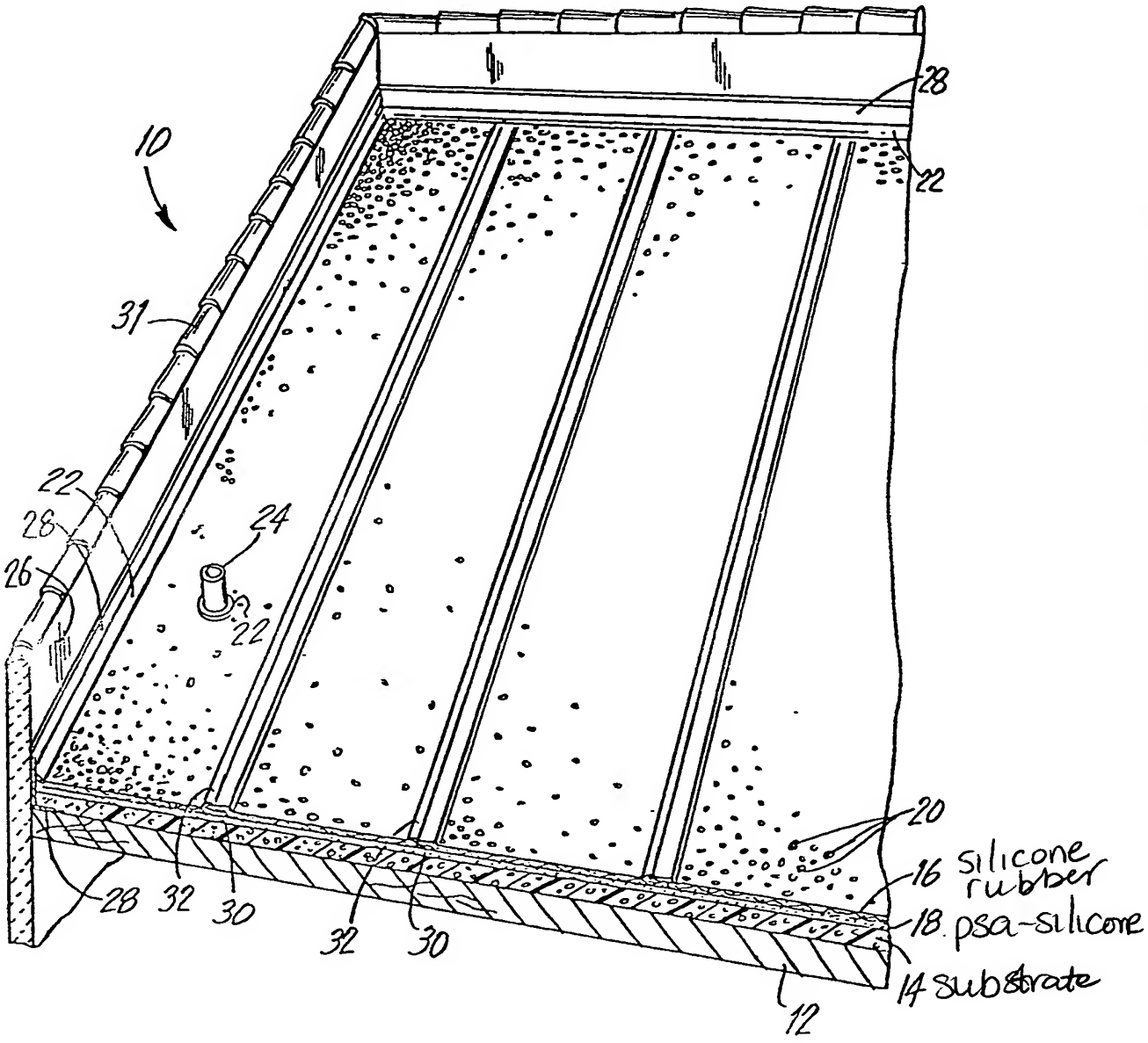

FIG. 1

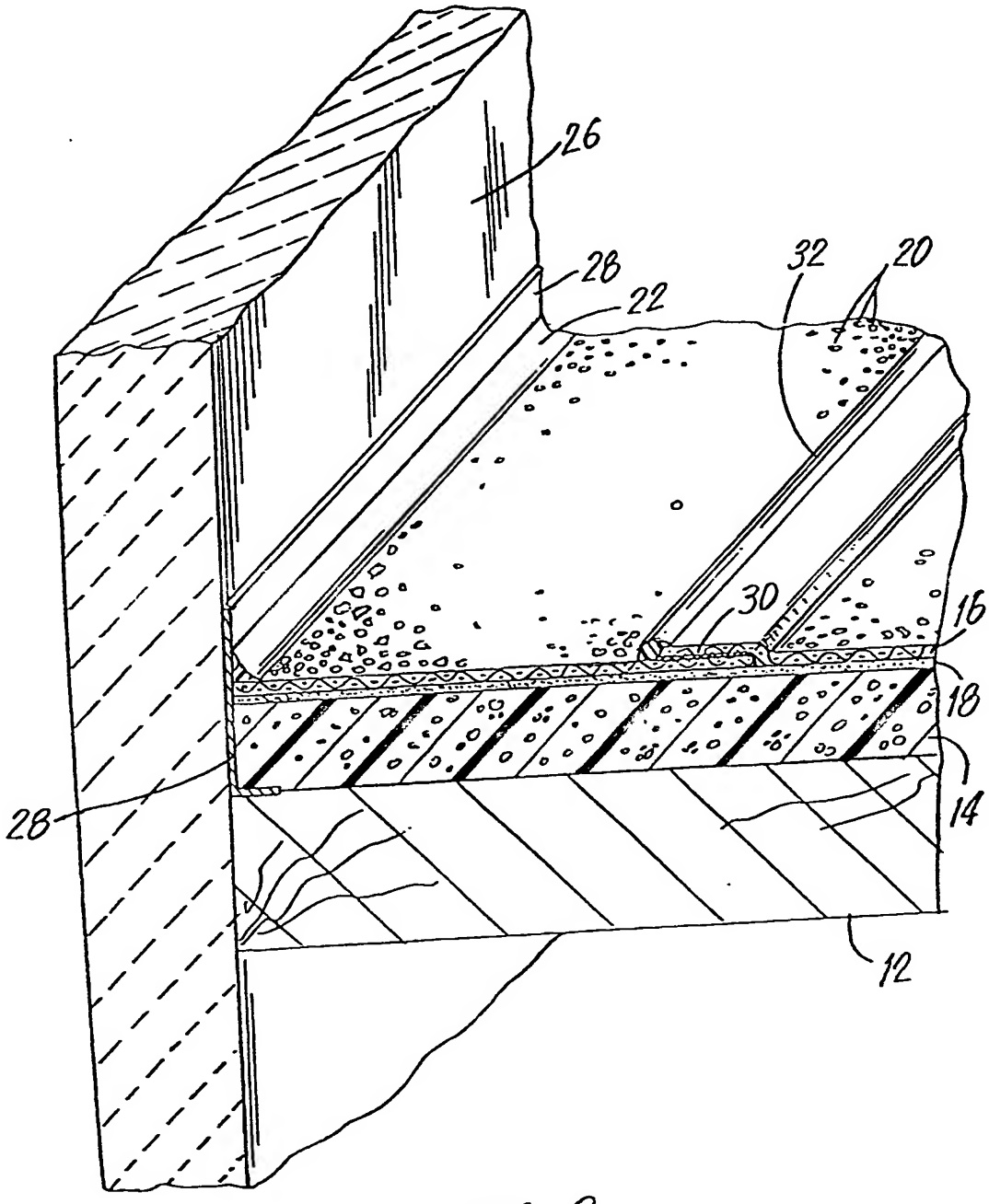

FIG. 2

SPECIFICATION

Silicone single-ply roofing system

The present invention relates to a roofing system for building and the like. More particularly it pertains to a silicone single-ply system for protecting new and existing roof decks from the effects of exposure to atmospheric elements such as sunlight, cold temperatures rain, wind, dust and the like.

In the majority of cases, the preparation of roofs generally comprises building up a protective layer starting from the underlying structure, typically, a roof deck. The so-called flat roofs are made by spreading tar or other organic adhesives on the deck, or on a substrate overlying the deck, e.g. asphalt impregnated felt, and then pressing fabrics or non-wovens into the organic material, then applying a second coat of asphalt, or other adhesive, and another layer of fabrics or non-wovens, and so on, until at least the minimum thickness necessary to insure weatherability is secured. A major problem with such a system is the loss of physical properties in the layers due to weathering--this leads to brittle cracking and permits water to enter. Sheet shrinkage also occurs due to interaction of ultraviolet light with the organic materials commonly used, and this leads to water leaks at edges, joints and seams. There is also a notable lack of compatability between the various roofing sheets of the prior art and the bonding layers employed, and this leads to lap seams opening up, permitting the wind to blow the composite open, again followed by the entry of water.

Many proposals have been advanced to improve the ways roofs are produced, but none have proved themselves to be entirely satisfactory. In Bessmer et al, U.S. 4,293,597, assigned to the same assignee as the present application, there is disclosed a method of forming a roofing composite by applying a self-bonding silicone rubber two package composition to a roofing substrate. While such a composition adheres very strongly and forms a cohesive bond between the roofing substrate and the coating, there is a tendency for the integrity of the coating to be impaired, for example, if struck by articles such as stones, hail and the like.

On the other hand, Olsen, U.S. 4,297,265, discloses flexible substrates such as glass fiber cloths coated with one package silicone rubber compositions, and proposes that they be applied "over existing roofing materials which are frequently petroleum or asphalt bases". The problem with this approach, as has been mentioned, is that the lack of compatibility between the materials will lead to loss of adhesion and subsequent failure. Furthermore, merely applying silicone coated glass fabric to a conventional multilayer system does not avoid at all the laborious procedure of building up the roof layer by layer as explained above. Fabric silicone elastomer composites are also known for other purposes, for example, Woodroof, U.S. 4,303,712 describes waterproof materials made from knitted fabrics coated with heat cured silicone rubbers for use in athletic clothing, and the use of room temperature vulcanizing silicones to seal lap joints in such fabrics is mentioned. Okamoto et al, U.S. 4,318,949, describe non-woven sheets or fabrics impregnated with room temperature vulcanizable organosilicones having a napped surface, smooth to the touch.

The roofing system of the present invention differs from the prior art by providing a composite comprising an insulation substrate and a silicone single ply glass fabric reinforced membrane as its essential features. Because the membrane is essentially silicone and glass the sheet will not exhibit loss of physical properties due to weathering, especially exposure to ultraviolet light. The membrane is to be either fully adhered to the substrate with a silicone pressure sensitive adhesive or sealed with a silicone sealant around the perimeter and ballasted. This will insure chemical compatibility between the roofing sheets and substrate and, if any lap seams are present, silicone will be used there, too, to prevent loss of adhesion and ultimate failure.

According to the present invention, there is provided a roofing system comprising:

(a) a roof deck;

(b) a roofing substrate overlying said roof deck; and

(c) a single ply membrane layer of glass fabric coated with a cured, room temperature vulcanizable silicone rubber overlying said roofing substrate (b), said single ply membrane layer (c) being firmly bonded to said substrate (b) by means of

(i) (d) a silicone rubber pressure sensitive adhesive,

(ii) (e) a silicone sealant bead around the perimeter of said membrane layer (c) bonding said layer to the roof in combination with (f) a ballasting layer of roofing granules, or

(iii) a combination of means (i) and (ii).

The present invention will be further described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view, partly in section of a flat roof made in accordance with the present invention; and

Figure 2 represents a view, enlarged, of a portion of Figure 1 illustrating a form of the invention in which the membrane is bonded to the substrate with an adhesive, and showing a sealed lap joint.

Referring to the drawings which illustrate preferred forms of the present invention, Figure 1 illustrates a portion of flat roof deck 10 comprising the composite system including roof 10 comprising the substrate 14 and glass-silicone single-ply membrane 16. Also shown in this embodiment is pressure sensitive silicone adhesive bonding layer 18. This can be omitted, and replaced with edge sealing and ballasting, as will be described later.

The single ply membrane 16 comprises a silicone pourable one package room temperature vulcanizable (RTV) composition coated over a glass fabric. While the fabric can be laid in place and coated in place with

the RTV silicone, it is preferred to pre-fabricate the membrane and then to deliver it to the place of end use. This will minimize construction steps. In any event, the preferred silicone one-package system will comprise, as is well known, a composition in which all the ingredients as well as the catalyst systems are mixed together and the composition is stored in an anhydrous state. As long as moisture does not come into contact with the composition, it does not cure. However, once the composition is applied to the glass fabric, either by coating, or dipping, or by other conventional means, and it then comes into contact with moisture in the air, or other types of moisture, it will cure rapidly to the final rubbery state. The one part RTV silicones are commonly classified according to the by-product that is evolved during cure. The four most common by-products are acetic acid, oxime, alcohol and acetamine. An acetic acid-liberating RTV silicone is used in making a preferred membrane of the present invention because of its excellent physical properties and weather exposure resistance. A suitable composition for use in coating the glass fabric is prepared following the teachings of Bruner, U.S. 3,035,016, Example 1: 16.74 parts of a hydroxylated dimethylsiloxane fluid are mixed with 2.23 parts of methyltriacetoxysilene and 10.15 parts of 2 cs trimethylsilyl endblocked dimethylsiloxane fluid. The mixture is heated at 100°C under reduced pressure for 1.5 hours and the acetic acid is removed as formed. The remaining acetic acid, excess methyltriacetoxysilane and the 2 cs fluid is then removed by vacuum distillation. The residual fluid is storage stable in the absence of moisture and cures in 1 to 1.5 hrs to form a rubbery product when exposed to the atmosphere. To facilitate the coating of glass fabrics, a small amount of solvent is added as a thinner—toluene or petroleum ether being suitable.

A 1-part RTV composition available from General Electric Company, Waterford, New York, U.S.A, RTV-112 can also be used.

In accordance with conventional techniques, the silicone composition, alone, or dissolved in the solvent is applied to the glass fabric by brushing, doctor blade, spraying, roller coating or the like. Thickness is adjustable and is dependent on the particular job. Curing occurs on exposure to moisture and leaves an outwardly presented silicone rubber surface in composite 16.

As has been mentioned, the present system can be applied to new and existing roof decks 12, which can be made of wood, metal, concrete, masonry, plastic or the like. Referring to Figure 2, insulation substrate 14 is first applied to roof deck 10, and this will comprise a conventional material, typically, but not limited to urethane foam board stock, vermiculite, spray applied urethane foam, or even asphalt impregnated felt. The thickness of layer 14 is not critical, but entirely conventional. Silicone membrane 16 is next applied to the insulation substrate 14, by any of a number of methods, e.g., by laying down glass fabric and brushing the RTV silicone composition onto it, or by laying down a prefabricated membrane. If a prefabricated membrane is used, membrane 16 can be either fully adhered to insulation substrate 14 or sealed only around the perimeter and ballasted, i.e., weighted down with roofing granules 20.

Also, if a formed-in-place membrane 16 is used, then to insure adhesion to insulation substrate 14, it is preferred to employ a silicone adhesive layer 18, especially preferrably a two-component pressure sensitive adhesive, because compitibility will be facilitated. Also, silicone adhesives of the pressure sensitive type will have longer "pot lives" or work times than conventional organic adhesives and because of their lower viscosities, contractors can cover more square feet per gallon keeping both total weight overhead and material consumption down.

In one of the preferred embodiments, the prefabricated membrane 16 is laid into a bead layer of silicone pressure sensitive adhesive 18, uniformly spread over insulation layer 14 and firmly pressed into contact with the adhesive. The pressure sensitive adhesive is a conventional material, for example, one of the two-component resin compositions described in commonly-assigned Modic, U.S. 3,017,384, can be used. Chemically, these will comprise a co-hydrolyzed mixture of a trialkyl hydrolyzable silane an and alkyl silicate and also a high viscosity organopolysiloxane fluid having terminal silicon-bonded hydroxy groups. These can be dissolved in a solvent, such as toluene and then mixed with a suitable catalyst, e.g., zinc octoate, dicumyl peroxide, tetrabutyl titanate, gamma-aminopropyltriethoxy siliane, etc. and applied to the insulating substrate 14. Evaporation of the solvent leaves a layer of pressure sensitive adhesive silicone 18 to which glass-silicone composite 16 adheres with great strength, and, in turn, layer 18 is strongly adherent to insulation substrate 14.

Two part pressure sensitive adhesives for this invention also can be made from commercial materials, as follows:

Ingredients	*Parts by Weight*
Part A	
Resin (Product No. PSA-6573 General Electric Co.,)	100
- or -	
Resin (Product No. PSA-529, General Electric Co.)	100
Part B	
Gamma-aminopropyl triethoxysilane	2.3 - 4.3
- or -	
Benzoyl peroxide	2.3 - 4.3

Part A is mixed with Part B immediately prior to use.

If the membrane 16 is to be edge bonded in accordance with another feature of the invention, then beads 22 of a silicone rubber sealant, to be described later, will be run around the entire perimeter to form a bridging seal between silicone control membrane 16 and any penetrations, pipes (24 in Figure 2), flashings 28 and the like in the construction. If edge sealing alone is relied on, then a method of maintaining contact between membrane 16 and insulation substrate 14 which can be employed is to provide ballasting with gravel or roofing granules 20. Of course, a combination of edge sealing with ballasting and the use of uniform adhesive layer 18 can also be used.

In those cases where single-ply silicone rubber membrane 16 is made from sheets of material, e.g., cut from rolls of three or four feet width and any convenient length, then it is preferred to provide lap seams of, for example, three to six inches and to splice the laps with silicone adhesive layer 30. This will comprise a pressure sensitive adhesive and preferably will be the same adhesive used to form layer 18. If lap seams are present, then in preferred embodiments bead 32 of a silicone sealant will be run along the top side of the lap seam to provide integrity.

The silicone sealant used as an edge seal 22 around pipes, penetrations, flashings, and top side 32 of any lap seam is a conventional one-part RTV material comprising a moisture reactive low modulus composition containing the usual additives and fillers to secure adhesion to different substrates. These are commonly available from several sources, e.g., from General Electric Company and are described in commonly assigned patents, such as Beers, U.S. 4,100,129 and Smith et al. U.S. 4,273,616. Exspecially useful results in roof coating systems are provided with a one component (titanium chelate catalyzed) material of the following composition:

Ingredient	*Parts by Weight*
25,000 viscosity, silanol terminated polydimethyl-siloxane	100
stearic acid treated calcium carbonate (filler)	100
50 cs methoxy terminated dimethoxylsiloxy diphenylsiloxy copolymer fluid containing 30 mole % diphenylsiloxy groups (thixotrope)	5
methyl trimethoxysilane (cross-linker)	0.5
1,3-dioxypropanetitanium-bis-ethyl acetoacetate (catalyst)	1.8
1,3,-tris-trimethoxysilylpropyl isocyanurate (adhesion promoter)	0.75

One hundred parts of a dry mixture of the first three ingredients are mixed with 3.05 parts of the last three ingredients and the mixture is stored in sealed packages out of contact with moisture until ready for use.

It will be apparent to those skilled in the art that various other forms of joints may be used. For example, instead of lap seams, edge abutted seams can be provided. These can be sealed with a bead of sealant. Alternately, they can be capped with a narrow strip of fabric or other covering material and, if desired, the edges can again be sealed. It is possible also to use more than a single ply of coated fabric membrane 16, but a major advantage– simplicity of construction–will be lost, without much gain, if any, in integrity.

Instead of woven glass fabric, knitted glass, non-woven forms, such as mats and felts can be substituted, and instead of glass, other materials, such as polymeric mats and fabrics, or mineral fibers may be substituted.

It will, accordingly, be apparent to those skilled in the art that various alterations, modifications, and changes may be made to the products and techniques herein described without departing from the scope of the present invention as set forth in the appended claims.

CLAIMS

1. A roofing system comprising:
(a) a roof deck;
(b) a roofing substrate overlying said roof deck; and
(c) a single ply membrane layer of glass fabric coated with a cured, room temperature vulcanizable silicone rubber overlying said roofing substrate (b), said single ply membrane layer (c) being firmly bonded to said substrate (b) by means of
(i) (d) a silicone rubber pressure sensitive adhesive,
(ii) (e) a silicone sealant bead around the perimeter of said membrane layer (c) bonding said layer to the roof in combination with (f) a ballasting layer of roofing granules, or
(iii) a combination of means (i) and (ii).

2. A roofing system as claimed in Claim 1 wherein said single ply membrane (c) is bonded to substrate (b) by means of (i) (d) a silicone rubber pressure sensitive adhesive.

3. A roofing system as claimed in Claim 1 or Claim 2 wherein said substrate is a urethane foam board stock, vermiculite, spray applied urethane foam or asphalt impregnated felt.

4. A roofing system as claimed in any one of the preceding claims wherein said cured, room temperature vulcanizable silicone rubber is prepared by curing a pourable one package composition.

5. A roofing system as claimed in any one of the preceding claims wherein said silicone pressure sensitive adhesive (d) is prepared by reacting a two component composition.

6. A roofing system as claimed in any one of the preceding claims wherein said single ply membrane layer (c) comprises lap-seamed sheets, the seams of which are adhesively bonded with said silicone rubber pressure sensitive adhesive (d).

7. A roofing system as claimed in any one of the preceding claims wherein said single ply membrane (c) is edge sealed at pipes, penetrations, flashings, if present, and on the top side of any lap seam with (e) a silicone rubber sealant.

8. A roofing system as claimed in Claim 7 wherein said silicone rubber sealant (e) is prepared by curing a one component catalyzed composition.

9. A roofing system as claimed in Claim 7 or Claim 8 wherein said silicone rubber sealant (e) is a moisture curable composition including a catalytic amount of a titanium chelate catalyst.

10. A roofing system as claimed in claim 1, substantially as hereinbefore described in any one of the examples.

11. A roofing system as claimed in Claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

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